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U. S. DEPARTMENT OF THE INTERIOR  
PROTOTYPE OIL SHALE LEASING PROGRAM

AIR QUALITY CONTROL PLAN  
FOR TRACT C-b

Submitted to:

Peter A. Rutledge  
Area Oil Shale Supervisor

By:

C-b Shale Oil Venture

Ashland Oil, Inc.  
Occidental Oil Shale, Inc., Operator

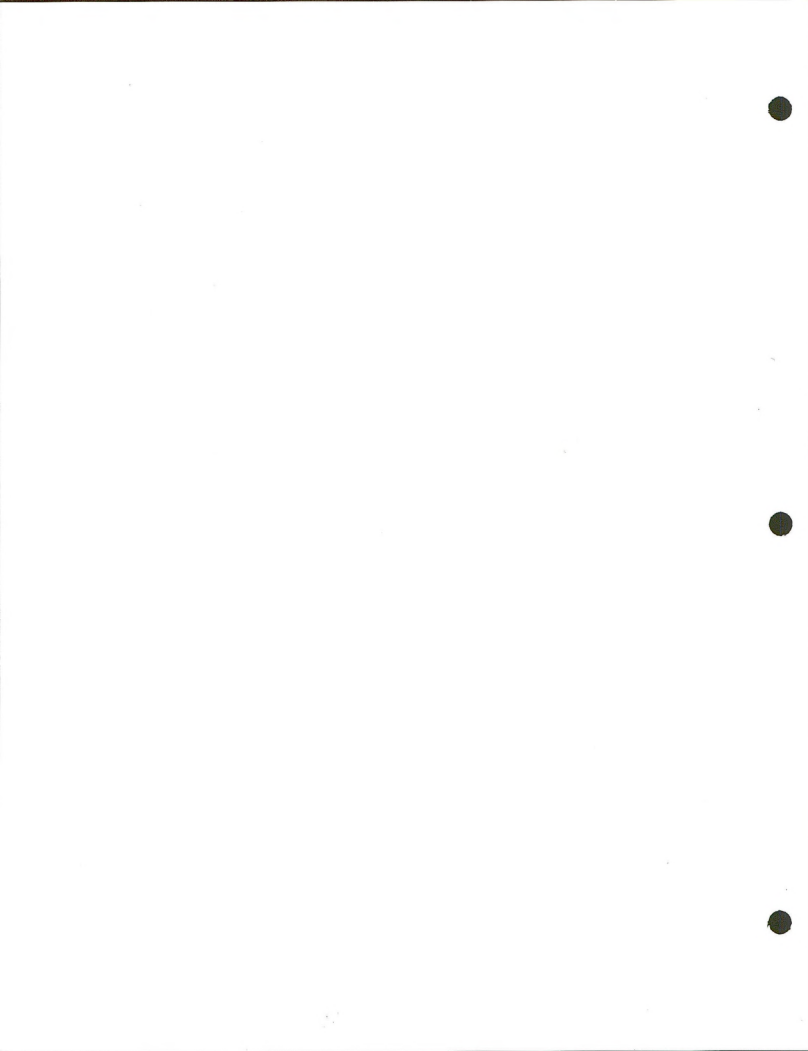
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App. A - Air Quality Control Plan for Tract C-b (Supplementary Information).  
June 10, 1977

App. B - Air Quality Control for Oil Shale Tract C-b (Supplementary Information).  
November 1, 1976

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## AIR QUALITY CONTROL PLAN

### 1. INTRODUCTION

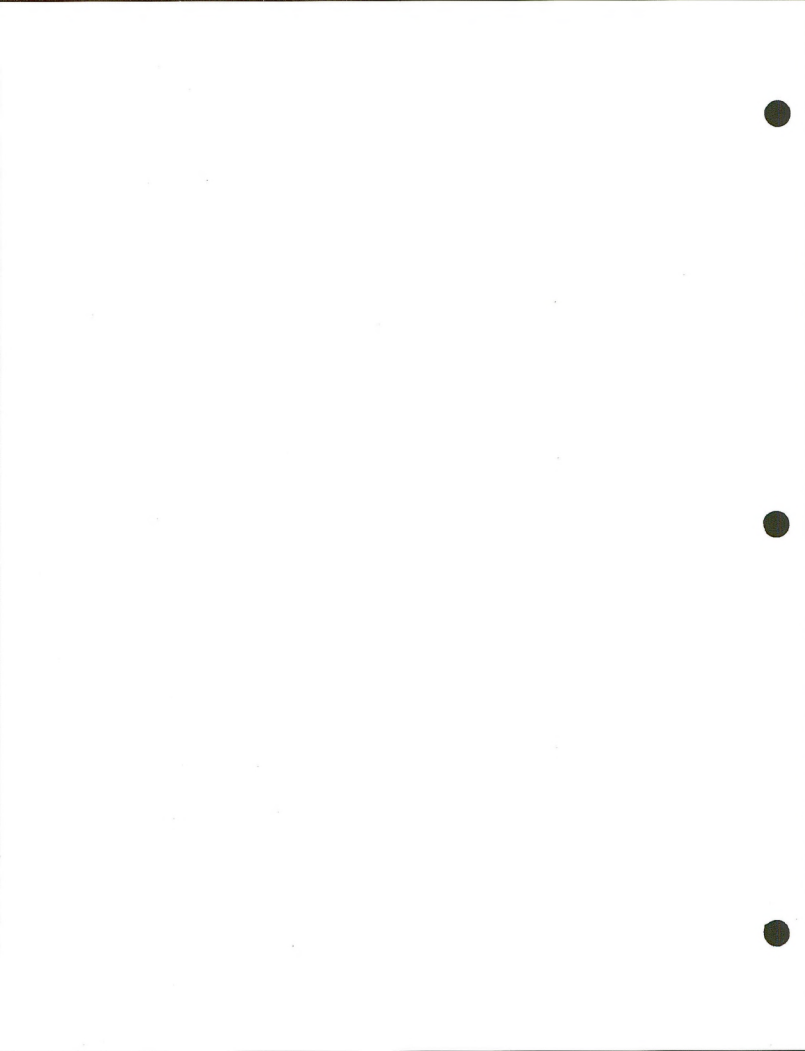
This air quality control plan is presented in two phases: The ancillary phase and commercial operations. This is entirely appropriate since 1) permits to construct are expected to be issued for each of these two phases, 2) more details are known at the present time for the earlier ancillary phase, and 3) improved rough-terrain air diffusion models and their inputs will exist at a later date to provide refined estimates for full-scale operations.

The control plan consists of an emission inventory by operational activity along with controls descriptions and efficiencies, citations of appropriate emission and ambient-air-quality standards, and demonstration of compliance by means of diffusion modeling.

Pollution sources can be categorized as point, line or area sources. Examples of these are: a stack; a line of traffic; and acreage of shale-storage piles. Process emission stacks are planned emission sources; leakages from storage tank domes, dust from unpaved roads and shale piles are defined as "fugitive". Sources can be on-tract or off-tract. The control plan recognizes and discusses these source types.

Before proceeding to a description of pollution control measures it should be noted that tall stacks will be used (except for dust originating at ground level) to effectively disperse the pollutants. Diffusion is usually enhanced in rough terrain, typified by the C-b site.

The numbers (sizes, flows, etc.) presented in this report are nominal values utilized in the modeling of the ancillary phase as presented to the Area Oil Shale Supervisor on June 2, 1977, representing the best estimates available as of that date. This material supplements that contained in Modifications to the Detailed Development Plan as submitted by the Lessees to the Area Oil Supervisor in February, 1977.





## 2. CONTROL PLAN FOR THE SHAFT-SINKING AND ANCILLARY-DEVELOPMENT PHASES

### 2.1 Emissions Inventory

#### 2.1.1 Shaft-Sinking Phase

In the shaft-sinking phase, seven activities are delineated as potential pollution sources in the emissions inventory on Table 2.1.1. These include: 1) access road; 2) temporary power generation; 3) site preparation; 4) mine shaft-shale transfer point; 5) transfer via diesel equipment; 6) shale crushing; 7) shale disposal. Dust is the sole pollutant considered in items 1), 3), 4), 6) and 7).

##### 2.1.1.1 Access Road

The main access road adjoins the preferred off-tract primary road corridor, as described in Modifications to the Detailed Development Plan (hereafter abbreviated MDDP), Section III. D.5. Approximate on-tract location is shown on Figure I-A in the MDDP. Appendix B presents the emission factor for unpaved roads (Pedco Report #9) as

$$\begin{aligned}\text{Emission factor} &= 0.27 (1.068)^V + 1.54 \\ (\text{lbs/veh. mi}) \\ \text{where } v &= \text{vehicle speed (MPH)}.\end{aligned}$$

Assuming a peak loading of 967 workers per shift in 2-man car pools with 50% shift overlap, there are 726 cars on the 4.2 mile access road for 0.21 hour at 20 mph. The above emission factor yields 2.5 lbs dust/vehicle-mile which translates into 36,300 lbs dust/hour over this time interval. The conclusion is that the major access road must be paved.

##### 2.1.1.2 Temporary Power Generation

In the early stages of the shaft-sinking phase, permanent power of the magnitude required is not available at the site. A combined bank of generator sets of approximately 10000 hp (7460 kw), equivalent to  $6.10 \times 10^8$  BTU on a 24-hour basis, will be used. Utilizing EPA Document AP-42 for fuel oil with 0.023% sulfur, expected emissions in lbs/day are: particulates 36.7,  $\text{SO}_2$  12.2 and  $\text{NO}_x$  513. No controls are required, so long as each generator in the bank is under 1000 hp and the bank is unmanifolded.

##### 2.1.1.3 Site Preparation

Figure III-A of the MDDP shows the location of the ancillary facilities at the three sites described on Page III-7:

<u>Site</u>	<u>Acreage Disturbed</u>
General Facilities Site	8
Gas Treatment Facilities	3
Steam Generation Facilities	3
TOTAL	14

From a fugitive dust standpoint, it is assumed that 25% of this total acreage is "exposed" at any one time. At an emission factor of 1.4 tons/ac/mo (EPA AP-42) and utilizing chemical stabilizers to achieve 80% control efficiency, the resulting emission rate is 2.7 lbs/hr.



TABLE 2.1-1

## ESTIMATED EMISSIONS INVENTORY DURING SHAFT - SINKING AND ANCILLARY DEVELOPMENT PHASES

PHASE	SOURCE OR ACTIVITY	MATERIAL HANDLING RATE	POLLUTANT	EMISSION FACTOR W/O CONTROL	EMISSIONS W/O CONTROL (lb/hr)	CONTROL MEASURE		EMISSIONS WITH CONTROL		STACK CHARACTERISTICS				
						DEVICE	EFFICIENCY (%)	(lb/hr)	ppm (1)	NUMBER	HEIGHT (m)	DIAM. (m)	VOL. FLOW (SCFM)	EXIT TEMP. (°F)
SITE PREPARATION & SHAFT SINKING	Access Road	4.2 mi, 25 mph, 3069 veh. mt	Fugitive Dust	$0.22 (1.06)^{1/4} + 1.54$ where $w =$ veh speed (mph)	(b) 26300 lb/hr	Pave Road	100	0						
	Temporary Power Generation	10,000 hp	Particulates SO <sub>2</sub> NO <sub>x</sub>	36.7 lb/day (0.0215) 12.2 lb/day 513 lb/day	(a) 1.5 0.5 21.4	Unmanifolded - No Control	0 0 0	1.5 0.5 21.4		10	4	0.5		
	Site Preparation	14 acres Disturbed (25% Exposed)	Dust	1.4 tons/ac/yr	(a) 13.6	Chemical Stabilizers	80	2.7						
	Mine Shaft Shale Transfer Pits	9400 tons/day	Dust	0.1 lb/ton	(d) 39.2	Wet Suppression	75	9.8						
	Surface Transfers via Diesel Equipment	Total Surface Diesel - 4000 gal/day SO <sub>2</sub> - 3 hr CO - 24 hr THC NO <sub>x</sub> 9400 tons shale/day 400 veh mt/day - shale tr.	Particulates SO <sub>2</sub> CO THC NO <sub>x</sub> Fugitive Dust	13 lb/1000 gal (0.0245) 2.7 lb/1000 gal 225 lb/1000 gal 457 lb/1000 gal 370 lb/1000 gal 1000 lb/day	(a) 2.2 0.5 37.5 6.2 61.7 (b) 41.7	Catalytic Converter	0 90 90 90 90 80	2.2 0.5 3.8 0.6 61.7 8.3						
	Shale Crushing	9400 tons/day	Dust	0.5 lb/ton	(c) 195.8	Baghouse	99	2.0		1	10	0.6	20000	Ambient
	Shale Disposal	9400 tons/day - 80 acres max.	Dust	8 tons/ac/yr	(b) 146.0	Chemical Stabilizers	80	29.2						
	Mix. Vent. - (Total including Mixing, Blasting, Handling & Hauling, Crushing, and Rubbling)	≤ 1 blast/shift; ≤ 70 times/year Diesel 7000 gal/day 41000 tons shale/day	Part. 24 hr Annual SO <sub>2</sub> - 3 hr Annual CO - 24 hr Annual CO - 1 hr Annual 8 hr Annual THC - 3 hr Annual NO <sub>x</sub> - Annual	See Table 2.1-2 for Emission sub-totals by activity and Table 2.1-3 for Emission Factors	1600 1500 45 7 2 2 2450 90 257 90 12 300	Baghouse Baghouse Diesel Equipment has Catalytic Converters for CO, HC	99 99 0 0 0 90 90 90 0 0	16 15 45 7 2 19140 2450 257 90 12 300	5.5 5.1 7.0 1.1 0.3 6781 869 91 2.9 0.6 64.8	1	88	3.3	636,534	>3° Above Ambient
	In-Situ Gas Treatment	102 Full Scale - assumed in modeling 81.5 BTU/SCF (SHV)	Particulates SO <sub>2</sub> CO THC NO <sub>x</sub>	1.17 lb/10 <sup>3</sup> ft <sup>3</sup> 1500 ppm H <sub>2</sub> S equiv. 1.33 lb/10 <sup>3</sup> ft <sup>3</sup> 0.234 lb/10 <sup>3</sup> ft <sup>3</sup> 9.36 lb/10 <sup>3</sup> ft <sup>3</sup>	(a) 7.4 1500 ppm H <sub>2</sub> S (a) 0.4 1.5 59	Stretford Unit followed by Thermal Oxidizer	0 99 0 0 0	7.4 17.4 8.4 1.5 59	6.5 7.2 7.9 0.2 33.6	1	25	4	240,000	400
	Steam Generator - (Boiler)	620 gal/day fuel oil, 100,000 lb/day boiler	Particulates SO <sub>2</sub> CO THC NO <sub>x</sub>	0.0225 Sulfur Fuel Oil; Non-Sulfur estimates from burning fuel oil	(a) 16.3 3.6 4.3 3.3 87	No Emission Controls	0 0 0 0 0	16.3 3.6 4.3 3.3 87	114.3 11.8 32.3 33.5 337	1	52	1.6	30,070	400
ANCILLARY DEVELOPMENT PHASE	Fuel Tank Storage	3.99 × 10 <sup>6</sup> gal/5 days 101 Full Scale Handling	THC (Fugitive)	Storage Loss: 0.0052 lb/dy (a) Work Loss: 1 lb/gal	(a) 0.0052 lb/dy (a) 1 lb/gal	Floating Roof Tanks		11						
	Mine Shaft - Conveyor Transfer Pt.	41000 tons/day	Dust	0.1 lb/ton	(d) 170.8	Wet Scrubber	99	1.7		1	10	1.2	80,000	Ambient
	Shale Conveyor	41000 tons/day	Dust	0.03 lb/ton	(d) 51.2	Continuous Wet Suppression and Chemical Addit.	85	7.7						
	Shale Disposal	41000 ton/day/80 ac. max.	Dust	8 tons/ac/yr	(b) 146	Chemical Stabilizers	80	29.2						

\* (a) EPA AP-42 (b) Pedco Rept #9 (c) Marshall and Agapito, Colony App 14 (d) Assumption

(1) ppm except for particulates which are ppw



#### 2.1.1.4 Mine Shaft - Shale Transfer Points

In this phase shale rock is transported from 5 shafts to the disposal area by truck:

<u>Shaft</u>	<u>Total Sinking Time</u>	<u>Span</u>
12' D Vent/Escape Shaft	15 mo.	'78 - Mid '79
34' D Production Shaft	17 mo.	'78 - Mid '79
34' D Service Shaft	17 mo.	'78 - Mid '79
6' D Tem. Gas Shaft	5 mo.	Sept. '79 - '80

A total of 16 million tons of rock from shaft sinking is removed up to the start of commercial operations on September 1, 1982 (i.e. over a 56-month span) for an average daily tonnage of 9400 tons/day.

An emission factor of 0.1 lb of dust per ton of shale rock has been assumed; wet suppression techniques with an efficiency of 75% reduce these emissions to 9.8 lbs/hr.

#### 2.1.1.5 Surface Transfers via Diesel Equipment

These include transfers of shale rock from the hoists at the shaft transfer points and general on-tract usage of diesel equipment for transportation, hauling, grading, etc. Approximately 4000 gal/day of diesel fuel are estimated for average surface usage.

EPA AP-42 has been utilized to estimate the emission factors listed in Table 2.1-1. Catalytic convertors with 90% efficiency reduce both CO and THC emissions. Sulfur content of the diesel fuel is assumed to be 0.02%.

Approximately 400 vehicle miles per day are estimated solely for transport of shale to the disposal area; this yields 1000 lb/day of fugitive dust, or 41.7 lbs/hour. Application of chemical stabilizers on a regular basis results in 80% control and reduces fugitive emissions to 8.3 lbs/hour.

#### 2.1.1.6 Shale Crushing

The surface crusher provides both construction fill at 6-12 inches in diameter and fill for Cottonwood Gulch. Marshall and Agapeto in Appendix 14 of the Colony Environmental Impact Statement estimated the dust from crushing to be 0.5 lbs/ton. At 9400 tons per day, this amounts to 195.8 lbs/hour. A baghouse collection device with 99% efficiency will reduce emissions to 2.0 lbs/hour. These emissions exit through a 10 meter stack.

#### 2.1.1.7 Shale Disposal

Emission factors for uncontrolled shale acreage have been estimated from Pedco Report #9 as 8 tons/acre/year. This reference also cites 50% control achieved through twice-per-day watering and 80% control through application of chemical stabilizers.

Appendix A yielded the result that approximately 80 acres of shale disposal chemically treated could comply with air pollution standards. Thus it is tentatively planned that no more than 80 acres will be unvegetated at any one time; this corresponds to an emission rate of 29.2 lbs/hr with 80% control. More refined estimates of emission factors for raw shale utilizing alternative



controls coupled with further work on vegetation techniques are warranted here inasmuch as fugitive dust from the raw shale pile proved to be one of the critical items from the initial modeling results. The sensitivity of allowable shale disposal acreage to emissions from the pile is as follows: -33 acres/ton/acre/year emission. (This is read as "a decrease of 33 acres of unvegetated shale is required for each ton per acre per year that emissions from the shale pile increase".) This points up the desirability of improving the accuracy of the emissions estimate.

It should be noted that fugitive dust on the Tract tends to be large particles. Generally such particle size is not associated with potential health hazards or diminished visibility.

## 2.1.2 Ancillary Development Phase

This plan and associated modeling assume that the ancillary-phase processing rate is 10% of full-scale operations or 5700 bbl/day. The mine is assumed to be operating at the full-scale rate of 41,000 tons of mined-out shale per day.

This plan includes full-scale development mining under ancillary development. In the development mining phase material produced during development of stations, access ways, service areas, and during the initial retort development will be crushed underground and transported to the 12' diameter shaft.

The emissions inventory for the ancillary phase is shown on Table 2.1-1. It includes the following sources or activities: 1) mine vent, 2) in-situ gas treatment, 3) steam generator, 4) fuel tank storage, 5) mine shaft-conveyor transfer point, 6) shale conveyor, and 7) shale disposal.

### 2.1.2.1 Mine Vent

The mine ventilation system requires an airflow of 636,534 scfm and utilizes a stack 88 meters in height. The height is constrained to be (approximately 10 feet) higher than the mine hoist-house for worker health and safety protection while working at the top of the hoist-house. Such height coupled with the large momentum flux of the mine-vent exhaust plume enhances plume diffusion in the atmosphere.

As described in the MDDP (Page III-26) the mining cycle in conventional room and pillar mining consists of drilling, charging the drilled face, blasting, wetting the blasted rock pile, loading, hauling, scaling and roof bolting.

The nominal rubbled-column retorts are 200 x 200 feet in plan and 310 feet in height. Only sufficient shale will be removed from within the retort volume to provide an approximate 20% to 25% void which redistributes by rubblelizing with conventional explosives to provide a uniformly bulked-full retort column.

This control plan identifies emissions from mining operations which flow through the mine vent stack as: "mining", blasting, handling and hauling by use of underground diesel equipment, crushing, and rubblelizing.

Table 2.1-1 shows the total emissions from the mine vent by pollutant. Blasting is expected to occur during shift changes, and its emissions are highly time dependent. They are presented for averaging times corresponding to air quality regulations; annual, 24-hour, 8-hour, 3-hour, and 1-hour. More detail regarding mine vent emissions is presented on Table 2.1-2. Emission-factor-related assumptions are presented on Table 2.1-3. Eighty percent control of the particulates produced in the mine is achieved by a combination of wet suppression





TABLE 2.1-2

MINE VENT EMISSIONS, LB/HR.

<u>Pollutant</u>	<u>Avg. Time</u>	<u>Mining, Blasting, Hauling, Crushing</u>	<u>Rubbling</u>	<u>Diesel Equipment</u>	<u>Total</u>
Particulates	24-hour	10.3	1.4	3.8	15.5
	Annual	10.3	0.3	3.8	14.4
SO <sub>2</sub>	3-hour	0.1	43.3	0.08	45
	24-hour	0.03	5.4	0.08	7
	Annual	0.03	1.1	0.08	2.0
CO	1-hour	274	18,800	65.6	19,140
	8-hour	34.3	2,350	65.6	2,450
	Annual	34.3	157	65.6	257
THC	3-hour	0.7	47	10.8	58.5
	Annual	0.3	1.2	10.8	12.3
NO <sub>x</sub>	Annual	34.3	157	108.2	299.5



TABLE 2.1-3

MINING EMISSION-FACTOR-RELATED ASSUMPTIONS

- 1) Rubbling is assumed to occur not more than once per 24-hour period and not more than 70 times per year.
- 2) It is assumed that 7,000 gallons of diesel fuel are burned underground daily. Diesel emissions are estimated from EPA AP-42, p. 3.1.5-2 and appear in Table 2.1-1 per 1000 gallons under "Surface transfers via diesel equipment". Diesel equipment use catalytic convertors.
- 3) Crushing is estimated to produce 0.5 lb. of particulates/ton of shale blasted; see EPA AP-42, Table 8-20.1. Blasting is estimated to produce no more particulates than crushing. Handling and hauling are estimated to produce no more particulates than two pounds per ton. Eighty per cent of the particulates produced are assumed to settle out in the mine (EPA AP-42). Collection efficiency of the balance is estimated at 99%. Five per cent of the particulates formed in rubbling are assumed to escape from the retort into the mine.
- 4) ANFO utilizing 6% fuel oil is assumed to be the explosive used in mining and rubbling. Fuel oil with 0.023% sulfur is assumed.
- 5) Blasting is assumed to produce 0.04 lb. of CO and 0.04 lb. of NO<sub>2</sub> per lb. of ANFO, due to non-ideal reaction behavior. Rubbling produces 18,800 lb. of CO once every 5 days.
- 6) It is assumed that 0.5% of the fuel oil in ANFO is not burned in blasting and comes out in the mine vent as hydrocarbons.



techniques and ordinary settling by the baffling provided by the multiplicity of rooms and passages. The  $\text{SO}_2$  in the ventilation air is controlled solely by selection of 0.02% low-sulfur fuels. The noxious gases produced from periodic blasting (at shift change) will be exhausted without control; their dispersion from the tall stack is more than adequate to keep ground level concentrations well below those required by air quality standards.

#### 2.1.2.2 In-Situ Gas Treatment

The retort offgas is treated to remove sulfur compounds before it is thermally oxidized. The assumption is made here, subject to detailed study at a later date, that organic sulfur compounds are sufficiently low in concentrations that they do not have to be removed. A Stretford or similar process is utilized to remove hydrogen sulfide down to a level that the overall sulfur content is not greater than 15 ppmv equivalent  $\text{H}_2\text{S}$  as the nominal design. Two design alternatives are presented in Sections 2.4.1 and 2.4.2. Inasmuch as  $\text{H}_2\text{S}$  levels are in the neighborhood of 1500 ppmv to the Stretford unit, this represents a control efficiency of 99%.

Burning the retort offgas will convert carbon monoxide and hydrocarbons to carbon dioxide and water. Particulates will be at very low levels. Residual sulfur compounds (i.e. after the removal process described above) will be converted to sulfur dioxide. Oxides of nitrogen will be kept to a minimum utilizing low burner temperatures and excess air. All pollutants will thus be at sufficiently low levels that they can be adequately dispersed by exhausting through a tall stack.

Non-sulfur pollutants in burned offgas were estimated as follows: An analysis of the fuel content of the offgas showed it to be essentially gaseous hydrocarbons. The overall carbon-to-hydrogen mole ratio is approximately 3 : 7, which compares with that of a mixture of half propane ( $\text{C}_3\text{H}_8$ ) and half propylene ( $\text{C}_3\text{H}_6$ ). Emission factors for gaseous fuels of this type are estimated by EPA ratioing the emission factors for natural gas and the fuel in question against their higher heating values (EPA AP-42, March 1975, pg. 1.5-2). This procedure was used for the offgas. The emission factors for natural gas were taken from page 1.4-2 of EPA AP-42, March 1975. The higher heating value for natural gas was taken as 1050 BTU/scf and the higher heating value from the offgas was taken as 81.9 BTU/scf.

#### 2.1.2.3 Steam-Generating Facilities

The 100,000 lbs/day boiler in the ancillary phase burns very low sulfur fuel oil (<0.023% by weight); in the full-scale operations it will burn offgas. Boiler flue gas is exhausted through a relatively tall stack without treatment. Estimates of the non-sulfur emissions have been obtained from EPA AP-42, (Table 1.3-1) as 16.3, 4.3, 3.3, and 87 lbs/hour for particulates, CO, THC and  $\text{NO}_x$  respectively.

Burned retort offgas and boiler exhausts will be hot (ca. 400°F). Thus, plume rises from their respective stacks will be significant.

#### 2.1.2.4 Fuel Tank Storage

Fugitive hydrocarbon losses are expected from floating-roof fuel tank storage. The figures for losses from "tank storage" also include



losses from handling product oil, whether stored or not. Full scale storage is assumed to be five days' production; storage in the ancillary phase is assumed to be 1/3 full scale. Handling capacity is assumed to be 10% of full scale. Hydrocarbon losses from storage are assumed to be equivalent to a distillate fuel and estimated to be 0.0052 lb/day/1000 gal.; working losses are estimated to be 1.0 lb/1000 gal. throughput (EPA AP-42, pp. 4.3-8,9).

#### 2.1.2.5 Mine Shaft-Conveyor Transfer Point

The 12' ventilation/escape shaft is also used as a temporary ore production shaft in the ancillary phase. In this mode, it is equipped with a headframe, double drum hoist and a ladderway with landings. Shale is transported up the shaft and transferred to a surface conveyor belt. An emission factor of 0.1 lb. of dust per ton of shale has been assumed. A wet scrubbing device with a 99% efficiency reduces emissions from 170.8 lb/hr to 1.7 lb/hr.

#### 2.1.2.6 Shale Conveyor

The 41,000 tons per day of mined-out shale are transported from the mine transfer point to the shale disposal area via conveyor belt. Emissions are estimated to be 0.03 lbs. of dust/ton of shale transported. Continuously applied wet suppression techniques (with chemical additives, if required) are assumed to achieve 85% control in reducing emissions from 51.3 to 7.7 lb/hr.

#### 2.1.2.7 Shale Disposal

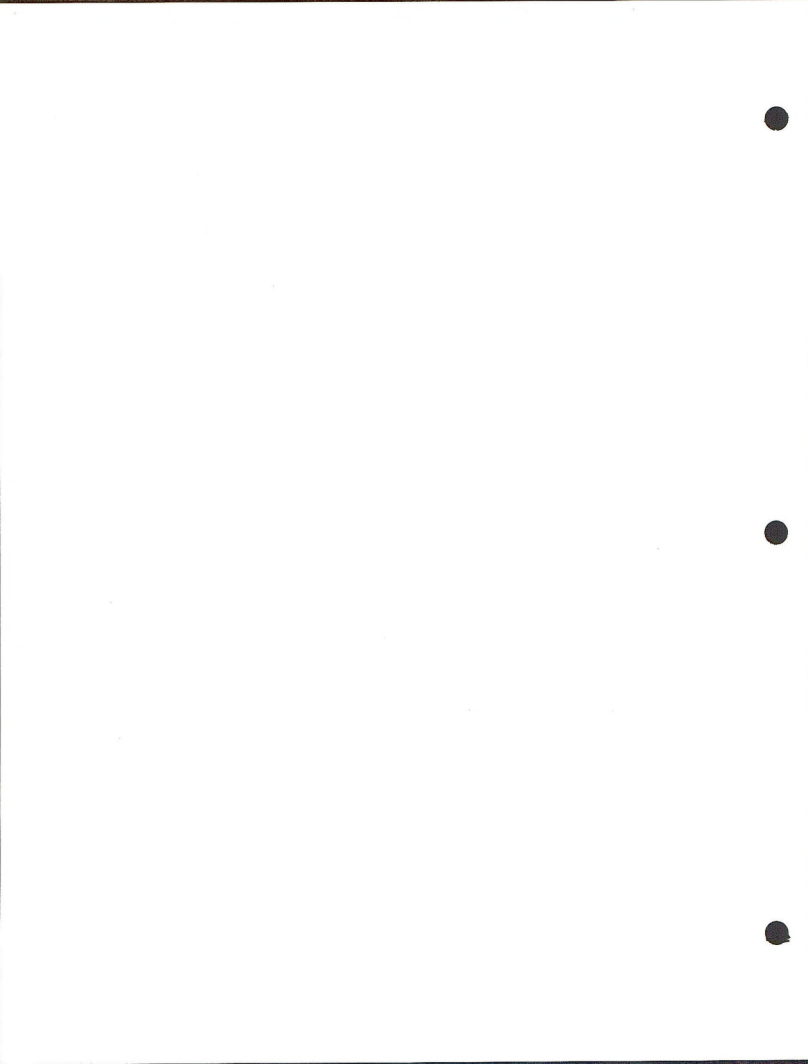
The same control applies here as was previously discussed in Section 2.1.1.7, the only difference being that the shale disposal rate increases from 9400 tons/day to 41,000 tons/day. Eighty acres is still the maximum anticipated unvegetated acreage at any one time.

### 2.2 Start-Up and Upset Conditions

From the standpoint of air pollution control, the significant aspects of start-ups and upsets are 1) the possibility that the offgas flow rate will be too low for good pollutant dispersion under these conditions, and 2) the possibility that either the Stretford plant or a boiler or thermal oxidizer will malfunction.

The offgas flow rate is itself not the critical flow; rather, the critical flow is the stack flow rate. If fewer retorts are in use than called for in the final design, the stack flow rate can be sustained by continuing to supply the necessary volume of air to the stack directly from the blowers. This will keep the exit velocity up and thereby help disperse the exhaust pollutants. Such a practice will lower the exhaust temperature somewhat, but counterbalancing this effect is the fact that there will also be a smaller amount of pollutants to disperse. This approach will not violate the regulation against dilution to meet emission limitations. Since emission levels will already be far below the emission limits; dilution is not being used to meet the limits.

The Stretford plant that removes hydrogen sulfide from the offgas will be modularized. Part of the plant can be out of commission without causing the complete plant shutdown. A measure of excess capacity can also be provided to take care of cases where just one or two modules are out-of-service. Also, a fraction of the operating retorts can be temporarily shut down if necessary in order to match the input to the Stretford plant with its active capacity.





The boilers or thermal oxidizers will also be modularized so that a segment can be non-operating without jeopardizing whole-plant operation. As before, if the active capacity of these units is less than required by the retort offgas, then some of the retorts can be shut down until the active capacity is adequate.

The duration of start-up or upset conditions depends on the degree of modularity. This is one of the design-optimization aspects to be addressed later this year.

Thermal oxidizers will be utilized during upset as opposed to direct flaring; this has the advantage of the added diffusion afforded by use of relatively tall stacks.

### 2.3 Potentially Hazardous Emissions

Potentially hazardous emissions that are envisioned are hydrogen sulfide, arsenic, arsine, and mercury. Polynuclear aromatics (PNA) and other carcinogens may possibly be potential problems for which additional information will be gathered early in the ancillary phase.

Estimates have been made for arsenic, arsine, and mercury for full-scale operations and are presented here. If compliance is achievable for full scale, it is more readily achieved for the ancillary phase.

#### 2.3.1 Hydrogen Sulfide

Hydrogen sulfide will be stripped from the offgas in the Stretford plant; any residue will be converted to sulfur dioxide when the offgas is burned. Thus, hydrogen sulfide will not be emitted to the atmosphere.

#### 2.3.2 Arsenic and Arsine

The exact levels of arsenic or arsine that may occur in the exhaust are not known, but it is known that arsenic accumulates preferentially in asphalts and other heavy ends of the product oil. Light fractions, i.e. those with boiling points less than 375°F, contain less than 2 ppm arsenic by weight. It is assumed that the arsenic content in the organic fraction of the offgas also does not exceed 2 ppm by weight. Two ppm by weight in the organic fraction of the offgas is equivalent to 0.52 ppm by weight in the exhaust.

Allowable concentrations of arsenic and arsine at ground level are calculated on the basis of Colorado Air Quality Control Regulation No. 8. This regulation limits ground level concentrations of a pollutant to 1/30 of its Threshold Limit Value (TLV), i.e. 0.5 mg/m<sup>3</sup> for arsenic and 0.2 mg/m<sup>3</sup> for arsine. The ground level concentration limits for arsenic and arsine are thus 17 ug/m<sup>3</sup> and 7 ug/m<sup>3</sup>, respectively.

The allowable ground level concentrations are then converted to allowable emission rates by using the dilution factor for the stack exhaust. The dilution factor is determined by knowing that the stack must be such that sulfur dioxide is diluted from 8 ppmv to 15 ug/m<sup>3</sup> (24-hour average), which is the most demanding dilution requirement. (Note: All effects are converted to moles and then converted back to concentrations by weight or volume as required.) The allowable emission rates are 19.5 ppm by weight for arsenic and 7.9 ppm by weight for arsine.



Thus if the allowable emission rates and the maximum expected emission rates are compared to determine if there is a potential problem, thirty-five times more arsenic and fifteen times more arsine could be emitted than is expected without violating Regulation No. 8.

### 2.3.3 Mercury

Mercury emissions have been estimated\* for full-scale operations utilizing Donnell and Shaw (1977)\*\*. They show that 2% of the initial mercury remains in the spent shale. Between 15 and 16% goes into the retort water (water from the retorting action). Twenty-five percent goes into the oil and 58% goes off in the gaseous products.

It is assumed that the dilution factor between the stack and the ground is that corresponding to dilution of 174 lb/hr of SO<sub>2</sub> at the stack to 15 ug/m<sup>3</sup> on the ground at the point of maximum impact (the Colorado Ambient incremental 24-hour standard). The 175 lb/hr from offgas burning corresponds to scrubbing the offgas to an equivalent H<sub>2</sub>S concentration of 15 ppmv before burning. Donnell and Shaw measured 0.43 ppm Hg in the shale by weight; thus .58 x 0.43 yields 0.25 ppmv Hg by weight in the offgas corresponding to a daily production rate of 48 lb/day. In full-scale, the boiler is powered by the offgas exhaust so that the concentration of mercury in the boiler exhaust is 0.027 ppmv. The dilution at ground level is 0.00083 ug mole/m<sup>3</sup>. The State of Colorado Regulation No. 8 allows 1/30 of a specified threshold limit value; this corresponds to 0.00166 ug mole/m<sup>3</sup> for alkyl mercury compounds. Thus our predicted emissions are one-half those allowable if all the mercury is in the form of alkyl compounds; the predicted emissions are approximately one-tenth those allowed if none of the mercury is in the form of alkyl compounds.

## 2.4 Design Alternatives

### 2.4.1 Alternatives to the Stretford Process

As previously stated, if the organic sulfur compounds prove to be sufficiently low in concentration, then the treatment will be with the Stretford or similar process to remove hydrogen sulfide. If organic sulfur compounds are too abundant (in terms of the sulfur dioxide they would form), they will be removed by other appropriate means such as alkaline scrubbing. Monoethanolamine (MEA) may be used to remove carbonyl sulfide and will remove hydrogen sulfide. The gas may then be further treated with a catalyst (e.g. UOP Mercox) and caustic; this will remove mercaptans. This sequence will eliminate the need for Stretford processing. Carbon dioxide may be recovered, if desired, from the MEA. In any event, the equipment selected would employ the best available commercial control technology to hold emissions below regulatory limits.

### 2.4.2 Decrease the Stretford Stripping Level

The nominal design strips the offgas down to 15 ppmv H<sub>2</sub>S equivalent. It was shown in the modeling study in Appendix A that stripping the offgas down to 83 ppmv H<sub>2</sub>S equivalent complied with all Federal and State air quality regulations. This will be further investigated as a design alternative.

\* Ruskin, A.M. - Memo to R.E. Thomason - 19 May 1977 - Mercury Emissions to the Atmosphere

\*\* Donnell, J.R. and Shaw, V.E.: Mercury in Oil Shale from the Mahogany Zone of the Green River Formation, Eastern Utah and Western Colorado, J. Res. U.S.G.S., 5, No. 2 - Mar-Apr 1977, pp 221-6.



#### 2.4.3 Alternatives to the Mine Vent Baghouse

Because of the large volume of mine ventilation air, the size of the baghouse is expected to be very large. Also, if the mine air were to be cleaned, it would be beneficial to the miners to clean it to a higher degree underground. Wet suppression techniques coupled with baffling, portable cyclones, and portable baghouses will be investigated as to feasibility for use underground.

#### 2.4.4 Shale Disposal Underground

The MDDP cites disposal of raw shale in the mine as a viable alternative for further study.

#### 2.5 Applicable Air Quality Standards

Table 2.5-1 presents three applicable groups of standards: 1) National Ambient Air Quality Standards (NAAQS), (Column 6), 2) Federal Prevention of Significant Deterioration (PSD) Regulations, (Column 7), and 3) State of Colorado Ambient Air Quality Standards, (Columns 8 and 9). Note that all NAAQS and the Colorado Ambient Standards for particulates are absolute values so that "background" values obtained from an environmental baseline must be added to oil-shale plant increments for comparison with these standards. PSD for SO<sub>2</sub> and particulates and Colorado standards for SO<sub>2</sub> are incremental values.

The background values obtained from C-b's two-year environmental baseline are presented in column 3 of Table 2.5-1. The reader is referred to the discussion on page 30 in the text of Appendix A relative to the high NMHC background levels. The Federal Register of December 21, 1976 recommends using annual particulates background for 24-hour PSD increments where the source is fugitive dust as has been demonstrated for C-b's particulates background.

Table 2.5-2 presents applicable emission limits (from stacks) from Regulation No. 1 of the Colorado Air Pollution Control Commission. They are given in lbs/10<sup>6</sup> BTU for particulates and ppmv for sulfur dioxide.

#### 2.6 Demonstration of Compliance

The EPA Valley model, as described in Appendix B, has been utilized to estimate maximum ground level concentrations due to the shale oil operations and associated fugitive sources. These modeling results for the ancillary phase are presented in Appendix A and summarized in column (4) of Table 2.5-1 at the "peak" receptor for all averaging times corresponding to air quality standards.

It is pertinent to review some of the major modeling conclusions:

1. All Federal and State Prevention-of-Significant-Deterioration standards are met everywhere for the ancillary phase.
2. Fugitive-dust concentrations have been estimated for the major access road and for the raw shale pile. It is concluded that:
  - a. The major access road must be paved.
  - b. The shale pile concentrations can be held within standards provided no more than 80 acres (unrevegetated) are exposed in any one year and 80% control is achieved by application of chemical stabilizers.
3. The nominal design for the offgas treatment facility utilizes a

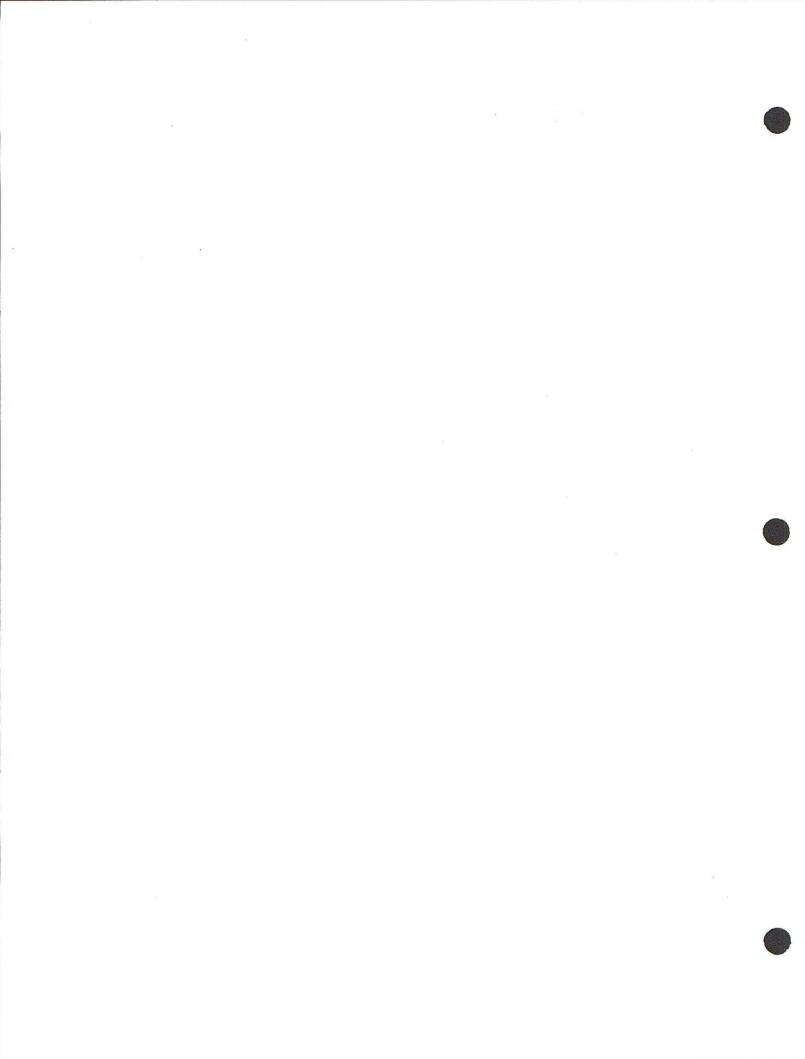


Table 5-1

COMPARISONS OF MAXIMUM GROUND-LEVEL CONCENTRATIONS IN THE  
ANCILLARY PHASE WITH STANDARDS ( $\mu\text{g}/\text{m}^3$ )

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Pollutant	Averaging Time	Appropriate Background Level	Modeling Increment	Sum (3) and (4)	NAAQS (A)	Standard		
						Federal (B) PSD (Class II)	Colorado Ambient (Cat. I)	
							Absolute (C)	Incremental (D)
SO <sub>2</sub>	Annual	1.3	0.2	1.5	80	15		3
	24-hour	112	3.7	115.7	365	100		15
	3-hour	87.7	14.8	102.5	1300	700		75
Particulates	Annual	10.7 <sup>(1)</sup>	9.3	20.0	60	10	45	
	24-hour	11.2 <sup>(2)</sup>	12.6	23.8	150	30	150	
NO <sub>2</sub>	Annual	21.0	6.6	27.6	100			
NMHC	3-hour (6-9 A.M.)	2597 <sup>(3)</sup>	26	2623 <sup>(3)</sup>	160			
CO	8-hour	4502	447	4949	10000			
	1-hour	4651	8714	13365	40000			
Oxidant	1-hour	160	0	160	160			

(1) Geometric Mean of 24-hour

(2) Arithmetic Mean of 24-hour as suggested in text

(3) See reference to page 30 of Appendix A in the text

(A)	Compare Columns (5) and (6)
(B)	" " (4) and (7)
(C)	" " (5) and (8)
(D)	" " (4) and (9)





TABLE 2.3-2

COMPARISON OF ANCILLARY AND FULL SCALE EMISSIONS WITH  
EMISSION LIMITS<sup>(1)</sup>

	<u>Emission Rate</u>	<u>Emission Limit</u>	
Particulates, lb/hr			
Ancillary Phase			
Burned Offgas	<7.4	108	0.1 lbs/10 <sup>6</sup> BTU
Oil Fired Boiler	16.3	20.3	0.14 lbs/10 <sup>6</sup> BTU
Full-Scale Operations			
Burned Offgas	<74	986	0.1 lbs/10 <sup>6</sup> BTU
Sulfur Dioxide, ppmv			
Ancillary Phase			
Burned Offgas	7.2	150	
Oil-Fired Boiler	11.8	150	
Full-Scale Operations			
Burned Offgas	7.8	150	

(1) Colorado Air Pollution Control Commission Regulation No. 1



Stretford type unit whose output is nominally at 15 ppmv equivalent H<sub>2</sub>S. For the stack configurations summarized on Table 2.1-1 with concentrations from the major sources (mine vent, steam generating facility, shale pile) fixed, emissions from the offgas treatment facility up to 83 ppmv equivalent H<sub>2</sub>S will meet all Federal and State PSD regulations.

#### 2.6.1 Compliance with Natural Ambient Air Quality Standards

Compliance with the NAAQS is demonstrated by comparing columns (5) and (6) of Table 2.5-1. Reference is again made to Page 30 of Appendix A for a discussion of the high NMHC background levels.

#### 2.6.2 With Federal PSD Regulations

By comparing column (4) of Table 2.5-1 with column (7) compliance is demonstrated with Federal PSD regulations for ground level concentrations at the "peak" receptor.

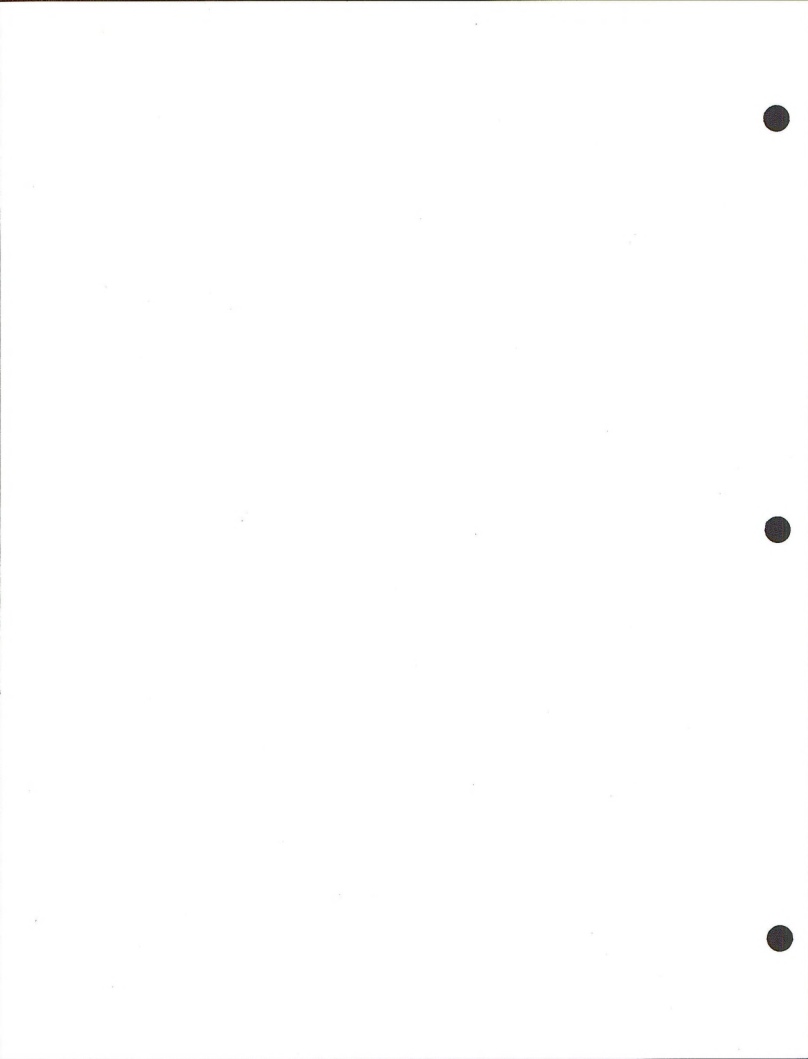
#### 2.6.3 With Colorado Ambient Standards

By comparing column (5) with (8) compliance with Colorado absolute standards for particulates is demonstrated. By comparing columns (4) and (9) compliance with Colorado incremental standards for SO<sub>2</sub> is demonstrated.

#### 2.6.4 With Colorado Emission Regulations

By comparing the emission rate from the ancillary facility in Table 2.5-2 with the emission limit from Colorado's Regulation No. 1 compliance is demonstrated. The regulation for particulate rates is stated in lbs/10<sup>6</sup> BTU units which is converted to lbs/hour on the table. Rates for SO<sub>2</sub> are specified in ppmv.

Note: Compliance with hazardous emission regulations has been addressed in Section 2.3.



### 3. CONTROL PLAN FOR COMMERCIAL OPERATIONS

It is to be noted that permits-to-construct from the State of Colorado are expected to be obtained by operational phases, i.e., a permit will be obtained initially for ancillary development, followed by full-scale operations at a later date. Engineering design details are available sooner for the ancillary phase than for full-scale; therefore, improved emissions estimates for full-scale will be available only in the future. Rough-terrain air diffusion models are undergoing rapid state-of-the-art improvements to more closely depict "real-life". Finally, "learning" from the ancillary phase will be applied to all permitting and modeling of full-scale in this phased approach. It is for all these reasons that the degree of detail for the full-scale control plan is less than that presented for the ancillary phase.

#### 3.1 Emissions Summary

Full-scale emissions are accompanied by explanatory and source footnotes summarized on Table 3.1-1 for the following major emission sources: 1) In-situ process (i.e., the off-gas treatment facilities), 2) the mine vent, 3) the shale disposal area, and 4) the fuel tank storage. The last column in the right lists the total emissions by pollutant as contained in Appendix B for the full-scale surface - retorting TOSCO II process which produced 50,000 bbl/day of oil for a mined-out shale tonnage of 66,000 tons/day over a 20 year mine life. The present in-situ process produces 57,000 bbl/day of oil for a mined-out shale tonnage of 41,000 tons/day over a 60 year mine life.

The mine vent emissions are identical to those of the ancillary phase since the mining for that phase is full-scale. The in-situ gas treatment facility is a scaled up modular version of the Stretford type (but see design alternative notes in Sections 2.4.1 and 2.4.2) utilized in the ancillary phase. In the commercial phase, boilers burn the off-gas from the Stretford plant instead of using fuel oil. There is one less stack for this combination as a result. The shale disposal pile operates under the same 80-acre acreage constraint as previously. Locations of the gas treatment and steam generating facilities change from those shown in Figure III-A for the ancillary phase to the location shown on Figure I-A on the MDDP.

#### 3.2 Demonstration Of Compliance

The method of approach is based on the following premises:

- 1) Modeling was investigated for the full-scale TOSCO II surface-retorting process (Appendix B). Compliance was demonstrated off-tract with all Federal and State Prevention-of-Significant-Deterioration regulations. The critical case corresponds to the 24-hour State standard for  $SO_2$  of  $15 \text{ ug/m}^3$  under Stable (F) conditions.
- 2) For the principal  $SO_2$  emitters, the in-situ process stacks are hotter and of higher volume flow than those for the TOSCO II process.
- 3) The total  $SO_2$  emissions are lower for the in-situ process (181 vs 251 lbs/hr).



TABLE 3.1-1  
FULL-SCALE EMISSIONS, lb/hr

Pollutant	Averaging Time	In-Situ Process <sup>1</sup>	Mine Vent <sup>2,3,4</sup>	Shale Disposal	Tank Storage	Total	Original DDP <sup>5</sup>
Particulates	24 hour	<74	16 <sup>6</sup>	29 <sup>7</sup>	-	<119	361
	Annual	<74	15 <sup>6</sup>	29 <sup>7</sup>	-	<118	
SO <sub>2</sub>	3 hr	174 <sup>8</sup>	45 <sup>9</sup>	-	-	219	251
	24 hr	174 <sup>8</sup>	7 <sup>9</sup>	-	-	181	
	Annual	174 <sup>8</sup>	2 <sup>9</sup>	-	-	176	
CO	1 hr	84	19,140 <sup>10</sup>	-	-	19,224 <sup>11</sup>	511
	8 hr	84	2,450 <sup>10</sup>	-	-	2,534 <sup>11</sup>	
	Annual	84	257 <sup>10</sup>	-	-	341 <sup>11</sup>	
THC	3 hr	15	59 <sup>12</sup>	-	103 <sup>13</sup>	177	353
	Annual	15	12	-	103 <sup>13</sup>	130	
NO <sub>x</sub>	Annual	588	300 <sup>14</sup>	-	-	888	1,996

<sup>1</sup> In situ emissions are estimated from the combustion of off-gas. Estimates are made from EPA AP-42 in proportion to higher heating values for gaseous fuels (used by EPA on page 1.5-2). No fuel burning above the combustion of off-gas is needed for power or heat.

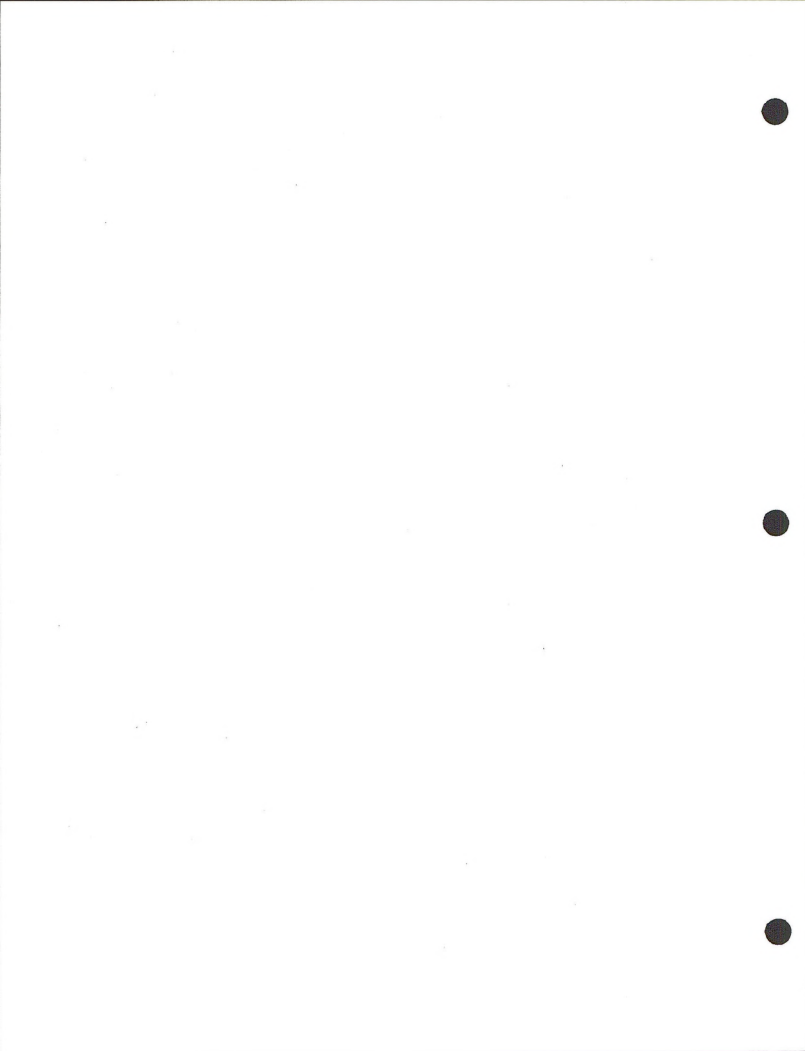
<sup>2</sup> Emission rates from the mine vent depend heavily on the amount of time over which the reaction products from a rubbing blast are averaged. Mine vent emissions are identical to those of the ancillary phase whose detailed breakdown is presented on Table 2.1-2.





TABLE 3.1-3 (Cont'd)

- 3 Rubbling is assumed to occur not more than once per 24-hour period and not more than 70 times per year.
- 4 It is assumed that 7,000 gallons of diesel fuel are burned underground daily. Diesel emissions are estimated from EPA AP-42, p. 3.1.5-2 and assume  $\leq 0.023\%$  sulfur by weight.
- 5 Figures for the original DDP plant design are from the report to the Area Oil Shale Supervisor dated 1 November 1976, enclosed here as Appendix B.
- 6 Crushing is estimated to produce 0.5 lb. of particulates/ton of shale blasted; see EPA AP-42, Table 8.20-1. Blasting is estimated to produce no more particulates than crushing. Handling and hauling are estimated to produce no more particulates than four times the amount produced on crushing. Eighty per cent of the particulates produced are assumed to settle out in the mine (EPA AP-42). Collection efficiency of the balance is estimated at 99%. Five per cent of the particulates formed in rubbling are assumed to escape from the retort into the mine.
- 7 The maximum acreage of raw shale exposed at any one time is estimated to be 80 acres. If emissions were uncontrolled, it is estimated that they would be 8 tons/acre/yr. Control of fugitive dust emissions from shale disposal operations is estimated to be 80%.
- 8 The Stretford plant is assumed to emit 15 ppmv  $H_2S$  maximum.
- 9 ANFO is assumed to be the explosive used in mining and rubbling. Fuel oil with 0.023% sulfur is assumed.
- 10 Blasting is assumed to produce 0.04 lb. of CO per lb of ANFO, due to non-ideal reaction behavior. Rubbling produces 18,800 lb of CO once every 5 days.
- 11 For pollutant dilution adequate for  $SO_2$  dispersal, the estimated ground level concentrations of CO are 3022  $\mu g/m^3$  for 1-hour averaging times and 268  $\mu g/m^3$  for 8-hour averaging times. These numbers are significantly less than the corresponding standards of 40,000  $\mu g/m^3$  and 10,000  $\mu g/m^3$ .
- 12 It is assumed that 0.5% of the fuel oil in ANFO is not burned in blasting and comes out the mine vent as hydrocarbons.
- 13 The figures for losses from "tank storage" also include losses from handling product oil, whether stored or not. Storage of five days' production is assumed. Storage losses are estimated to be 0.0052 lb/day/1000 gallons and working losses are estimated at 1.0 lb/1000 gallons throughout (EPA AP-42, pp. 4.3-8.9).
- 14 Blasting is assumed to produce 0.04 lb of  $NO_2$  per lb of ANFO, due to non-ideal reaction behavior.



### 3.2 Demonstration Of Compliance - Cont'd

4) The implication of item 2) is that the exhaust plumes from the stacks for the in-situ process will rise higher causing additional pollutant dispersion and lower ground level concentrations for the in-situ process. (Note that "effective" stack height is the sum of actual height plus plume rise derived from its buoyancy or momentum or both). Effective stack heights are shown on Table 3.2-1 and are higher for the in-situ case.

5) One additional consideration is that the mine vent for the TOSCO II was not reported to contain  $\text{SO}_2$ , but is considered for the in-situ process as a relatively small emitter ( $\leq 4\%$  of the total  $\text{SO}_2$ ). Its plume rise for a stable case is 48 meters at a wind speed of 2 m/sec; with an 88 m stack height its effective stack height is 136 m. Because of the relatively low percentage contribution of the mine vent to  $\text{SO}_2$  emissions this is deemed to be only of minor consequence.

6) Since by item 3) the emissions are lower for in-situ and by item 4) the plume rises higher, the ground level maximum concentration of  $\text{SO}_2$  for the in-situ process is lower than that for the TOSCO II process and will therefore comply with Federal and State PSD regulations.

Comparisons of  $\text{SO}_2$  and particulates with the State of Colorado emission regulations for full-scale operations are made on Table 2.5-2 demonstrating compliance.



TABLE 3.2-1

COMPARISON OF EFFECTIVE STACK HEIGHTS FOR THE  
MAJOR SO<sub>2</sub> EMITTERS IN THE TOSCO II SURFACE -  
RETORTING AND THE IN-SITU PROCESS

<u>PROCESS</u>	<u>EMITTER</u>	<u>STACK HEIGHT (m)</u>	<u>PLUME RISE (m)</u> <sup>*</sup>	<u>EFFECTIVE STACK HEIGHT (m)</u>
TOSCO II	Preheater	125	107	232
	Elutriator	↓	91	216
	Sulfur Plant	↓	50	175
IN-SITU	Gas Treatment	25	217	242

\* F Stability, 2 m/sec wind



APPENDIX A  
AIR QUALITY CONTROL PLAN FOR  
TRACT C-b

Dated June 10, 1977

(This supplementary information contains  
modeling results for in in-situ ancillary  
phase)





· APPENDIX B  
AIR QUALITY CONTROL FOR  
OIL SHALE TRACT C-b

Dated November 1, 1976

(Supplementary Information)

NOTE: This contains the modeling results for the full-scale surface-retorting TOSCO II process.

